CLOTHESPIN TYPE HEAT DISSIPATING APPARATUS FOR SEMICONDUCTOR MODULE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority from Korean Patent Application No. 2003-8450, filed on February 11, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This disclosure relates to a semiconductor module, and more particularly, to a clothespin type heat dissipating apparatus that can effectively dissipate heat generated by a device mounted on a semiconductor module and which can be easily attached to and detached from the semiconductor module.

2. Description of the Related Art

Recently, the thermal issue of semiconductor modules, such as, high density memory modules, becomes more critical. Along with the concerns about increasing power consumption and heat generation, which have arisen from the expectation that the capacity of memory modules will increase by up to 2 GB or more, there has been a need for a solution to the thermal issues associated with such memory modules.

As the rate of data transmission between a central processing unit (CPU) and peripheral devices becomes faster, the operating current of memory products becomes greater. To raise the capacity of memory modules, stacking more individual electronic components upon one another has been suggested. However, stacked memory modules result in poor thermal resistance.

A higher temperature of modules leads to a lower operation rate, poor refresh properties, and a shorter life span. For example, the data retention time (tREF) of Dynamic Random Access Memory (DRAMs) is a very critical factor. When the temperature, i.e., the device junction temperature (Tj), of a module rises 10° C, the data retention time is reduced by about 30%. As the temperature of memory modules increases, the yield decreases. Therefore, there is a need to keep the device junction temperature (Tj) constant without raising thermal problems.

Such a memory module is mounted in a slot of a mother board in a (personal) computer system, as shown in FIG. 1.

FIG. 1 is a diagram illustrating conventional memory modules mounted on a printed circuit board. Referring to FIG. 1, individual devices 13, which generally have a package form, are integrated on a module board 10 to form a memory module 14. The memory module 14 is inserted in a slot 11. About three or four slots 11 are spaced a distance of, for example, about 9.55 mm apart from one another, and a plurality of memory modules 14 are inserted in the slots 11 parallel to each other.

The temperature of the memory modules 14 varies depending on the positions of the devices 13 therein. The temperature of a memory module 14 at both end portions thereof is about 92° C, whereas the temperature of the memory module 14 at the center portion is about 132° C. This is because a larger amount of air flows at the end portions to facilitate thermal convection, whereas the air flows more slowly at the center portion and hot air flows towards the center portion from the front portion.

Such a rise in the temperature of the memory module 14 becomes more serious when the interval between a plurality of memory modules 14 inserted into the slots 11 is narrower. In particular, when each memory device 13 mounted in a limited area of the memory model 14 is highly integrated with more stacks, the problem of temperature rise is at its worst. This is because the interval between the modules 14 becomes narrower as the package has more stacks. For the double-side stacked memory module 14 as shown in FIG. 1, the interval between the modules is only 3.55 mm, which leads to more serious rises in temperature.

To compensate for the rise in temperature in such memory modules, various kinds of heat dissipating apparatus, for example, a heat sink or a heat spreader, have been attached to memory modules.

For example, for RAMBUS DRAMs, heat spreaders are disposed with a module therebetween and bound together by rebating. However, the heat spreaders rather hinder airflow and thermal convection when the modules are narrowly spaced with highly stacked packages and fail to dissipate or distribute heat.

In U.S. Patent No. 5,966,287, entitled "Clip-on Heat Exchanger for a Memory Module and Assembly Method," two parts, each of which includes a heat spreader and a heat sink, are arranged with a memory module therebetween and bound together using a clip.

However, with the above methods of coupling the heat dissipating apparatuses to a memory module by rebating or clipping, attaching or detaching the heat spreader or heat sink to/from the memory module is a complicated process.

The following are considerations required when attaching a heat sink or heat spreader to memory modules. First, the heat spreader or heatsink must tightly contact the individual components, i.e., the packages, of the memory module to lower contact resistance and more effectively transfer heat. Second, it must be easy to attach a heat spreader to or detach it from a memory module. Third, heat spreaders must be designed to induce more effective thermal convection.

However, as described above, the conventional coupling methods are complicated and do not allow tight binding between the heat spreader and the chip packages of the module. Therefore, a more effective heat dissipating apparatus that may be conveniently attached or detached from memory modules is required.

Embodiments of the invention address these and other limitations of the prior art.

SUMMARY OF THE INVENTION

The present invention provides a heat dissipating apparatus that can be easily attached to and detached from a semiconductor module and which can effectively dissipate heat generated by components (packages) of the semiconductor module to prevent a rise in the temperature of the semiconductor module.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages of the invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings.

FIG. 1 is a diagram illustrating conventional memory modules mounted on a mother board.

FIG. 2 is a diagram illustrating a clothespin type heat dissipating apparatus for memory modules according to an embodiment of the invention.

FIG. 3 is an exploded perspective diagram of the heat dissipating apparatus shown in FIG. 2.

FIG. 4 is a perspective diagram illustrating a process of installing the heat dissipating apparatus of FIG. 2 on a memory module.

FIG. 5 is a perspective diagram illustrating the heat dissipating apparatus of FIG. 2 installed on a memory module.

FIG. 6 is a cross-sectional diagram of FIG. 5.

FIGS. 7 and 8 are cross-sectional diagrams illustrating examples of heat dissipating portions for the heat dissipating apparatus according to some embodiments of the invention.

FIGS. 9, 10, 11, and 12 are cross-sectional diagrams illustrating examples of a biasing member for the heat dissipating apparatus according to some embodiments of the invention.

FIGS. 13, 14, 15, 16, and 17 are cross-sectional diagrams illustrating examples of thermal interface material layers that may be formed in the heat dissipating apparatus according to some embodiments of the invention.

FIGS. 18, 19, and 20 are graphs of heat resistance vs. position for various airflow rates that illustrate the effectiveness of embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the invention will be described with reference to the appended drawings. The invention may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art. It is also noted that like reference numerals may be used to designate identical or corresponding parts throughout the several views.

In the following embodiments according to the invention, a clothespin type heat dissipating apparatus is described that effectively dissipates heat generated by packages of a semiconductor memory module to prevent a rise in the temperature of the semiconductor memory module.

A clothespin type heat dissipating apparatus according to an embodiment of the invention includes two heat exchanger members, which are substantially symmetrical, disposed with a memory module therebetween. Each of the heat exchanger members may act as a heat sink and a heat spreader. These two heat exchanger members are hinged by a connection member for pivot movability. The connection member is positioned between the

heat exchange members. In particular, each heat exchange member includes a contacting portion, which contacts the memory module, and a heat dissipating portion, which extends like a fin above the memory module. The connection member is positioned between the heat dissipating portion and the contacting portion. As such, the two heat exchange members can clip the memory module while being hinged about the connection member.

To provide a force pushing the heat exchange members closer the packages mounted on a board of the memory module, a biasing member, for example, a spring may be inserted between the heat exchange members.

The contacting portion of each heat exchange member, which contacts the packages of the memory module, acts as a heat sink. The heat dissipating portions extending from the contacting portions, respectively, above the memory module inserted between the contacting portions effectively dissipate heat transmitted via the contacting portions into air by thermal convection.

Each of the contacting portions may include a heat transfer layer made of a thermal interface material (TIM) to ensure more effective heat transfer between the contacting portion of the heat exchange member and the packages of the memory module. A recess that will be filled with TIM may be formed in each of the contacting portions for tighter contact with the memory module. To provide against a case where the TIM is changed into liquid phase by the heat generated by the packages, either a packing member or a barrier may be formed around the TIM material layer to prevent it from running out of the recess.

The clothespin type heat dissipating apparatus according to embodiments.of the invention may be easily attached to and detached from a memory module by simple clipping. In addition, due to the biasing force or tension applied by the biasing member, tight contact between the heat exchange members and the memory module is ensured, thereby maximizing the efficiency of transmitting heat from the package to the heat exchange members.

The heat transmitted from the packages is transmitted to the heat dissipating portions of the heat dissipating apparatus. Since the heat dissipating portions protrude above the memory module inserted between the contacting portions to induce thermal convection, it can quickly dissipate the heat transferred from the packages into air. As a result, a rise in the temperature of the memory module can be effectively prevented.

FIG. 2 is a diagram illustrating a clothespin-type, heat-dissipating apparatus for memory modules according to an embodiment of the invention. FIG. 3 is an exploded

perspective diagram of the heat dissipating apparatus shown in FIG. 2. FIG. 4 is a perspective diagram illustrating a process of installing the heat dissipating apparatus of FIG. 2 on a memory module. FIG. 5 is a perspective diagram illustrating the heat dissipating apparatus of FIG. 2 installed on a memory module, and FIG. 6 is a cross-sectional diagram of FIG. 5.

Referring to FIGS. 2 and 6, a clothespin type heat dissipating apparatus according to an embodiment of the invention includes two heat exchange members 100 and 200, which are hinge jointed together for clipping, like a clothespin.

In particular, a first heat exchange member 100 and a second heat exchange member 200 may be formed to be substantially the same, for example, to be flat, although other shapes may be used depending on the operating environment. The first heat exchange member 100 includes a first contacting portion 110 and a first heat dissipating portion 130 extending from the first contacting portion 110. Likewise, the second heat exchange member 200, which corresponds to the first heat exchange member 100, includes a second contacting portion 210 and a second heat dissipating portion 230 extending from the second contacting portion 210. The first contacting portion 110 is thermally connected to the first heat dissipating portion 130, and the second contacting portion 210 is thermally connected to the second heat dissipating portion 240.

The first contacting portion 110 substantially contacts a package 530 (see FIG. 4), which is an electronic part, on a semiconductor memory module 500. The second contacting portion 210 does the same for an electronic part on the other side of the memory module 500. As shown in FIGS. 5 and 6, the semiconductor memory module 500 is inserted between the first and second contacting portions 110 and 210 so that the surfaces of the package 530 on a board 510 of the semiconductor memory module 500 contact the first and second contacting portions 110 and 210, as shown in FIGS. 4 and 6.

The first contacting portion 110 and/or the second contacting portion 210 contact the surface of the package 530 so that heat generated by the package 530 when the memory module 500 is operated in a computer is transferred to the first and second contacting portions 110 and 210. The first and second contacting portions 110 and 210 act as heat sinks. A TIM layer 600 (see FIG. 6), which will be described later, is formed on an inner surface of each of the first and second contacting portions 110 and 210 for tighter and closer contact between the first and/or second contacting portions 110 and 210 and the package 530.

The first heat dissipating portion 130, which extends from the first contacting portion 110 and is thermally connected thereto, is positioned to protrude above the memory module 500 that is clamped between heat dissipating apparatus, as shown in FIGS. 5 and 6. When the heat dissipating apparatus is coupled to the memory module 500, as shown in FIG. 5, the outer surfaces of the first and second heat dissipating portions 130 and 230 are exposed to the air so that they can effectively dissipate into air the heat transmitted from the first and/or second contacting portions 110 and 210. In other words, there is no blockage of airflow between the first and second heat dissipating portions 130 and 230, thereby allowing smooth thermal convection. As a result, heat can be effectively dissipated through the first and second heat dissipating portions 130 and 230. As such, the first and second heat dissipating portions 130 and 230 substantially act as effective heat spreaders.

The first and second heat dissipating portions 130 and 230, which protrude, like fins, above the memory module 500, may be designed to have a relatively large surface area for effective heat dissipating or heat transfer into air. To this end, the first and second heat dissipating portions 130 and 320 may have uneven surfaces, as shown in FIGS. 7 and 8. Alternatively, the first and second heat dissipating portions 130 and 320 may be formed of a metal plate, for example, aluminum, with porous surfaces.

The heat dissipating apparatus according to embodiments of the invention can effectively cool the package 530 by maximizing a thermal convection effect and can be easily attached to or detached from the semiconductor memory module 500 by simple clipping.

Referring back to FIGS. 2 through 6, the first and second heat exchange members 100 and 200 are hinge joined together by a connection portion 300. The connection portion 300 may include a hinge 310 and a pin 350, which is passed through the hinge 310. The first and second heat exchange members 100 and 200 can do hinging movements about the connection portion 300. When inserting the semiconductor memory module 500 between the first and second contacting portions 110 and 210 of the heat exchange members 100 and 200, the first and second contacting portions 110 and 210 are opened wide, as shown in FIG. 4, the memory module 500 is inserted between the first and second contacting portions 110 and 210, and the first and second contacting portions 110 and 210 are closed, as shown in FIG. 5.

To keep the first and second contacting portions 110 and 210 in contact with the memory module 500, as shown in FIG. 6, a biasing member 400 (see FIGS. 4 and 5) is disposed between the first and second heat dissipating portions 130 and 230. The biasing

force 400 between the first and second heat dissipating portions 130 and 230 provides a force pushing the first and second contacting portions 110 and 210 toward the memory module 500, due to the hinged structure of the heat dissipating apparatus.

For example, a spring may be installed between the first and second heat dissipating portions 130 and 230 as the biasing member 400, as shown in FIG. 2. The spring provides a force pushing the first and second heat dissipating portions 130 and 230 outward, as indicated by arrows in FIG. 2. At the same time, the first and second contacting portions 110 and 210 are pushed inward by the force of the spring due to the hinged structure of the first and second heat exchange members 100 connected by the connection portion 300.

In other words, when the first and second heat dissipating portions 130 and 230 are pushed in the directions indicated by arrows in FIG. 4, the first and second contacting portions 110 and 210 are opened to allow for the semiconductor memory module 500 to be inserted therebetween. When the first and second heat dissipating portions 130 and 230 are released from the force after the semiconductor memory module 500 has been inserted between the first and second contacting portions 110 and 210, the first and second heat dissipating portions 130 and 230 are pushed apart by the restoring force of the biasing member 400, as indicated by arrows in FIG. 5. This force is transmitted to the first and second contacting portions 110 and 210 via the connection portion 300 so that they become tightly affixed to the memory module 500.

FIGS. 9, 10, 11, and 12 are cross-sectional diagrams illustrating examples of a biasing member for the heat dissipating apparatus according to some embodiments of the invention.

The biasing member 400 may have various shapes, as shown in FIGS. 9 through 12. For example, a spring 410 may be used for the biasing member 400, as shown in FIG. 9. A plate spring 420 or 430 may be used for the biasing member 400, as shown in FIGS. 10 and 11.

Alternatively, a C-shaped spring 440 may be used, as shown in FIG. 12. In this case, the ends of the C-shaped spring 440 may be connected to the external surfaces of the first and second contacting portions 110 and 210 and the C-shaped spring 440 is oriented such that the connection portion 300 is included in the space formed by the C-shaped spring 440.

The heat dissipating apparatus according to embodiments of the invention is structured like a clip and utilizes the elastic force of the elastic member 400 to attach the first and second contacting portions 110 and 210 to the memory module 500. A heat dissipating

apparatus having such a structure may be conveniently attached or detached from the memory module 500 by simple clipping.

Referring to FIG. 6, for tighter contact between the contacting portions 110 and 210 and the packages 530 and effective heat transmission from the package 530, TIM layers 600 may be formed between the package 530 and the first and second contacting portions 110 and 210, as described above. Examples of a material for the TIM layers 600 include thermal tape, thermal grease, a thermal epoxy, and a phase change material, for instance.

FIGS. 13, 14, 15, 16, and 17 are cross-sectional diagrams illustrating examples of thermal interface material layers that may be formed in the heat dissipating apparatus according to some embodiments of the invention.

As shown in FIG. 13, the TIM layers 600 may be formed on surfaces of the first and second contacting portions 110 and 210 that face the package 530. As shown in FIGS. 14 and 15, to raise the efficiency of heat transmission from the package 530, a recess 610 may be formed in the surface of each of the first and second contacting portions 110 and 130, and the recess 610 filled with the TIM layer 600. The recess 610 filled with the TIM layer 600 provides more stable adhesion to the package 530.

Alternatively, as shown in FIGS. 16 and 17, a barrier or a packing member 700 may be provided adjacent to the TIM layer 600. The barrier or packing member 700 may be made of rubber, or other acceptable material. The barrier or packing member 700, which bounds the TIM layer 600 filling the recess 610, prevents the TIM layer 600 from dripping down the sides of the apparatus. When the TIM layer 600 is in liquid form or is made of a PCM that changes into a liquid at an elevated temperature, or when the temperature of the package 530 is raised, the TIM layer 600 could otherwise drip down the sides of the apparatus. The barrier or the packing member 700 prevents this problem.

The surfaces of the first and second contacting portions 110 and 210 that face the package 530 may be processed to be rough or to increase the surface area to maximize the adhesion to the semiconductor memory module 500. To this end, the surfaces of the first and second contacting portions 110 and 210 may be processed by etching, sputtering, coating, etc.

As described above, the temperature of semiconductor memory modules can be effectively maintained at a lower temperature using the above heat dissipating apparatus according to embodiments of the invention.

FIGS. 18, 19, and 20 are graphs of heat resistance vs. position for various airflow rates that illustrate the effectiveness of embodiments of the invention. FIG. 18 is derived from the case where no heat dissipation apparatus is used on a semiconductor memory module. FIG. 19 is derived from the case where a conventional rebated heat spreader is used on a semiconductor memory module, and FIG. 20 is derived from the case where an embodiment of the invention was used to dissipate heat from a semiconductor memory module.

The semiconductor memory module 500, in which nine packages 530 are mounted, as shown in FIG. 4, was used to obtain each set of results shown in FIGS, 18-20. Positions 1, 2, 3, 4, and 5 denote the first, third, fifth, seventh, and ninth package from the left end of the semiconductor memory module 500, respectively. In other words, positions 1 and 5 correspond to the leftmost package and the rightmost package, respectively, and position 3 corresponds to the middle package. Thermal resistance was measured at different air flow rates, in which the airflow moved in a direction from position 1 towards position 5.

A smaller value of heat resistance implies a greater cooling effect. Comparing the results in FIG. 20 to the results in FIGS. 18 and 19, it is apparent that the heat dissipating apparatus according to embodiments of the invention can effectively lower the temperature of memory modules and can evenly distribute the temperature of memory modules.

In conclusion, a clothespin type heat dissipating apparatus according to embodiments of the invention can easily be attached to or detached from a semiconductor memory module by simple clipping. The heat dissipating apparatus has fin-like heat dissipating portions that protrude above the semiconductor memory module, so that it can effectively dissipate heat into air by convection.

The heat dissipating apparatus according to some embodiments of the invention has recesses in the contacting portions thereof and packing members, so that a TIM material that changes into liquid by heat absorption can be effectively applied to the heat dissipating apparatus. Therefore, a rise in the temperature of semiconductor memory modules can be effectively prevented using the heat dissipating apparatus.

Furthermore, embodiments of the invention evenly control the distribution of temperature over the semiconductor memory module, without uneven rises in the temperature of a particular package of the semiconductor memory module.

Particular embodiments of the invention will now be described, but those embodiments shall not be considered to limit the invention nor prohibit the invention from operating in a different manner.

Some embodiments of the invention provide a clothespin type heat dissipating apparatus for semiconductor modules, the apparatus including: two heat exchange members, which are arranged facing each other with a semiconductor module therebetween, the semiconductor module including a plurality of packages; a connection member formed in the middle of each of the heat exchange members to hinge join the heat exchange members such that portions of the heat exchange members protrude above the semiconductor module inserted between the heat exchange members; and a biasing member disposed between the heat exchange members to provide a force pushing portions of the heat exchange members below the connection member toward the packages of the semiconductor module.

Other embodiments of the invention provide a clothespin type heat dissipating apparatus for semiconductor modules, including: a first heat exchange member including a first contacting portion, which is arranged in contact with a surface of a semiconductor module to absorb heat generated by the semiconductor module, and a first heat dissipating portion, which is thermally connected to the first contacting portion to dissipate the heat absorbed by the first contacting portion; a second heat exchange member including a second contacting portion, which is arranged in contact with the other surface of the semiconductor module to absorb the heat generated by the semiconductor module, and a second heat dissipating portion, which is thermally connected to the second contacting portion to dissipate the heat absorbed by the second contacting portion; and an elastic member providing a force pushing the first and second contacting portions toward the surfaces of the semiconductor module inserted between the first and second contacting portions.

In some embodiments of the invention, the portions of the heat exchange members that protrude above the semiconductor module may have uneven surfaces. In alternative embodiments of the invention, the portions of the heat exchange members that protrude above the semiconductor module may be made of a metal plate, for example, aluminum, with a porous surface.

The biasing member may be a C-shaped spring whose both ends go through the first and second heat dissipating portions and are connected to external surfaces of the first and

second contacting portions and which is oriented such that the connection portion is included in the space formed by the C-shaped spring.

Embodiments of the invention may further include a connection member, which hinge joins the first and second heat exchange members such that the first and second heat dissipating portions protrude above the semiconductor module inserted between the heat exchange members, wherein the biasing member may be one of a spring, a plate spring, and a C-shaped spring, which is disposed between the first and second heat dissipating portions and provides the force pushing the first and second contacting portions toward the surfaces of the semiconductor module inserted between the first and second contacting portions due to the force of the biasing member being exerted outward on the first and second heat dissipating portions.

Embodiments of the invention may further include a thermal interface material layer on the portions of the heat exchange portions below the connection member, which contact the surfaces of the packages. In alternative embodiments of the invention, the thermal interface material layer may be made of one selected from the group consisting of a thermal tape, a thermal grease, a thermal epoxy, and a phase change material.

In some embodiments of the invention, the portions of the heat exchange portions below the connection member, which contact the surfaces of the packages, are subjected to surface processing selected from the group consisting of etching, sputtering, and coating, to enhance the adhesion to the semiconductor module.

Other embodiments of the invention provide a clothespin type heat dissipating apparatus for semiconductor modules, including: a first heat exchange member including a first contacting portion, which is arranged in contact with a surface of a semiconductor module to absorb heat generated by the semiconductor module, and a first heat dissipating portion with uneven surfaces, the first heat dissipating portion being thermally connected to the first contacting portion to dissipate the heat absorbed by the first contacting portion; a second heat exchange member including a second contacting portion, which is arranged in contact with the other surface of the semiconductor module to absorb the heat generated by the semiconductor module, and a second heat dissipating portion with uneven surface, the second heat dissipating portion being thermally connected to the second contacting portion to dissipate the heat absorbed by the second contacting portion; a connection member, which hinge joins the first and second heat exchange units such that the first and second heat

dissipating portions protrude above the semiconductor module inserted between the first and second heat exchange members; and an elastic member disposed between the first and second heat exchange members to provide a force pushing the first and second contacting portions toward the surfaces of the semiconductor module inserted between the first and second contacting portions.

Other embodiments of the invention provide a clothespin type heat dissipating apparatus for semiconductor modules, including: a first heat exchange member including a first contacting portion, which is arranged in contact with a surface of a semiconductor module to absorb heat generated by the semiconductor module, and a first heat dissipating portion, which is thermally connected to the first contacting portion to dissipate the heat absorbed by the first contacting portion; a second heat exchange member including a second contacting portion, which is arranged in contact with the other surface of the semiconductor module to absorb the heat generated by the semiconductor module, and a second heat dissipating portion, which is thermally connected to the second contacting portion to dissipate the heat absorbed by the second contacting portion; a connection member, which hinge joins the first and second heat exchange units such that the first and second heat dissipating portions protrude above the semiconductor module inserted between the heat exchange members; an elastic member disposed between the first and second heat exchange members to provide a force pushing the first and second contacting portions toward the surfaces of the semiconductor module inserted between the first and second contacting portions; thermal interface material layers formed between the surfaces of the semiconductor module and facing surfaces of the first and second contacting portions; and packing members bounding the thermal interface material layers formed on the first and second contacting portions, respectively, to prevent the thermal interface material layers from running down the facing surfaces of the first and second contacting portions if the thermal interface material reaches a liquid or semi-liquid state.

In some embodiments of the invention, the packing members may be made of rubber. The facing surfaces of the first and second contacting portions may include a recess filled with the corresponding thermal interface material layer. Each of the packing members may be disposed around the corresponding recess.

As described above, embodiments of the invention have heat dissipating portions that protrude above a semiconductor module, and can effectively dissipate heat generated by the

semiconductor module. In addition, embodiments of the invention can be easily attached to and detached from the semiconductor module by a simple clipping process.

While the invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.